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## Hanoi's Urban Transformation in the 19<sup>th</sup> and 20<sup>th</sup> Centuries: An Area Informatics Approach

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### Abstract

The project Development of Area Informatics: With Emphasis on Southeast Asia (FY2005–09) [Shibayama 2005: 1] aims to create a new discipline called “area informatics,” an approach that integrates the interdisciplinary field of informatics with area studies, which encompasses all academic disciplines, including natural ecology, environmental studies, human ecology, sociology, history, cultural studies, economics and political science. One of the core research topics of this project is the process of urban formation in Hanoi in the 19<sup>th</sup> and 20<sup>th</sup> centuries. This research aims to explain the history of urban development in Hanoi, which has been the capital of Vietnam for 1,000 years, and to digitize the research process and its results for publication. To explain the process of Hanoi's urban development and transformation based on the hypothesis—“*Through the continual filling in of lakes and ponds formed by the riverbed of the old Red River, Hanoi achieved significant urban development and transformation during the Nguyen Dynasty period*”—generated by Sakurai [Sakurai and Shibayama 2007: 37], research into this process was furthered through spatial analyses of various data gathered during the project, including maps, satellite images, cadastral maps and historic ruins and vestiges, carried out using GIS (Geographical Information Systems) and RS (Remote Sensing) technologies. This paper discusses the analyses of urban transformation in the 19<sup>th</sup> and 20<sup>th</sup> centuries with the main emphasis on the urbanized city, water areas, and pre-colonial villages.

**Keywords:** Hanoi, urbanization, area informatics, French colonial period, Historical GIS

### I Urban Formation and Transformation in Hanoi in the 19<sup>th</sup> and 20<sup>th</sup> Centuries

Sakurai and Shibayama are conducting research into the process of urban formation and transformation from the 19<sup>th</sup> century through 21<sup>st</sup> century in Hanoi, the capital of Vietnam [Sakurai and Shibayama 2007: 37; Shibayama and Yonezawa 2008: 222]. The source materials used in this research include various geographical materials, such as maps and a cadastral document [Phan 2006] that the project researchers have gathered, data from 150 vestige and historic sites, information about ancient structures that have survived [Yonezawa and

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Shibayama *et al.* 2008: 27], information about modern architecture from the French colonial period and later [Ota 2006], and historic relics [Sakurai and Shibayama 2007: 37], based on field research conducted in the old quarter (Pho Co district). Based on these materials, individual studies have been conducted employing different methods. Sakurai used a historical area study approach, while Shibayama used an informatics approach. In this paper, the author attempts to prove Sakurai's hypotheses using an informatics approach.

Sakurai has generated the following hypothesis concerning the urbanization and transformation of Hanoi from the latter half of the 19<sup>th</sup> century through the beginning of the 20<sup>th</sup> century based on maps and other materials that were gathered [*ibid.* 2007: 37].

Hanoi was positioned on a natural embankment in the center of the Red River Delta, and many lakes and ponds formed by the riverbed of the old Red River remained at the base of the natural embankment. Through the continual filling in of these lakes and ponds, Hanoi achieved significant urban development and transformation during the Nguyen Dynasty period (1802–1945).

To prove this hypothesis, the author used spatial information technology from GIS and RS as well as informatics to analyze basic materials such as maps [Shibayama 2005: 1], satellite images, a cadastral document and an illustrated village map [Yonezawa and Shibayama *et al.* 2008: 27]. The specific methods and procedures for proving the hypothesis are as follows. First, a broad survey of urbanization and transformation from the latter half of the 19<sup>th</sup> century through the beginning of the 20<sup>th</sup> century was undertaken. Second, the evidence for and substance of “significant urban development and transformation” had to be investigated. To do this, (1) first a 1:2,000 vector map (digital map that can be handled in the GIS system) that would serve as a reference was created based on maps and satellite images. Then GIS technologies were used to compare and analyze such features as buildings, levees and land cover in the period 1873–1936. In addition, (2) in order to look down and understand characteristics of Hanoi's transformation on descriptions and events described in the cadastral document with corresponding to historical maps based on the viewpoint of spatiotemporal transition, it was necessary to accurately grasp the administrative classifications, especially village locations and boundaries that existed in the pre-colonial period and the French colonial period onward. To do this, the relative geographical positions of the villages in 1888 based on the cadastral document were established. An informatics approach including GIS technology and Network theory\*<sup>1</sup> were attempted in order to restore the districts, wards and villages. Next, (3) the geographical and topographical environment and conditions required for a discussion of Hanoi's urban formation were investigated. For this purpose, a three-dimensional (3D) landscape model was built based on elevation data (DEM: Digital Elevation Model) obtained from maps. A 3D landscape model makes it easier for readers to understand urbanization through visualizing the features on the ground such as buildings, roads, water streams, and so on from all angles.

## II Urban Transformation during the French Colonial Period: Spatial Analyses Using Map Comparisons

Using maps from 1873, 1885, 1890, 1894, 1898, 1902 and 1936, it was possible to clarify the following features by roughly dividing the Hanoi area into three areas as shown in Fig. 1: (i) Thang Long citadel and the surrounding area, enclosed in solid square in Fig. 1, (ii) the old quarter on the east side of the citadel (Pho Co district), between the citadel and the Red River, and (iii) the natural embankment positioned in the area from the west bank of the Red River to the area south of Thang Long citadel, as shown by the thin solid line in Fig. 1.

Analyses on evidence for and substance of “significant urban development and transformation” described above had been carried out by focusing on features that particularly differentiate the French colonial period from other periods. Such features are as follows. (1) Urban development planning progressed in the Thang Long citadel and its surroundings during the French colonial period, and in the 1890s, the walls and moats around the citadel disappeared. (2) Ponds and lakes in the old quarter in the Pho Co district decreased in the 1890s, and new streets and urban development emerged. Also, during this period, levee construction provided greater protection against catastrophic flooding, and the development of the old quarter proceeded at an accelerated rate. (3) During the approximately 10 years from 1890 to 1900, urbanization rapidly proceeded westward from the west bank of the Red River to the south side of the Thang Long citadel. (4) The current streets in Hanoi were created during the urban



Fig. 1 Three Areas in Central Hanoi



Fig. 2(a) Citadel in 1885 with Current Roads (dotted lines) in 2005



**Fig. 2(b)** Citadel in 1894 with Current Roads (dotted lines) in 2005



**Fig. 2(c)** Citadel in 1902 with Current Roads in 2005

development from the French colonial period onward and were mostly completed by 1936, except for the area near Bay Mau lake, south side of the citadel.

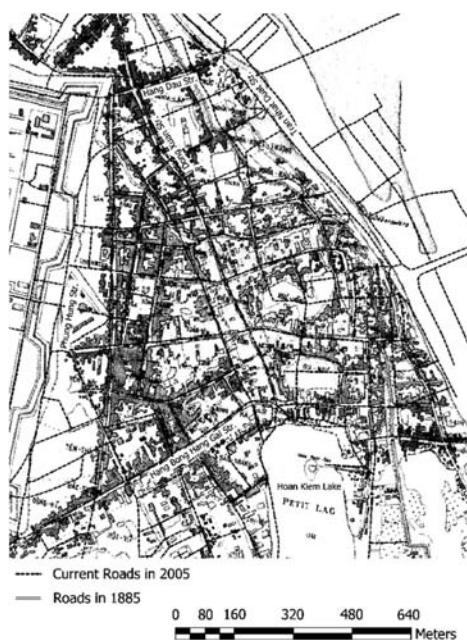
#### *Survival of Thang Long Citadel*

To examine the survival of Thang Long citadel, the maps from 1885 to 1902 were superimposed on the 2005 digital map. The differences are shown in Fig. 2. The year 1885 in Fig. 2 (a) was immediately after the French colonial period started. The fortress of the Thang Long citadel is accurately depicted in the 1885 map, but no evidence of the fortress or the moat remains in present-day Hanoi, other than the square pattern of the streets (see the dotted lines in Fig. 2 (a)). The fortress of the Thang Long citadel is also depicted in Fig. 2 (a); and in the next decade, barracks and the military plant were increasing inside the citadel along Phung Hung Str., as shown in Fig. 2 (b). By 1902, the wall and moat of the fortress had completely disappeared, although the barracks and military plant inside the right side of the citadel remained, as shown in Fig. 2 (c). Therefore, the destruction of the wall and moat progressed rapidly in the decade or so after the year 1890.

#### *Transformation in the Old Quarter, the Pho Co District*

Urban transformation between 1885 and 1902 is shown in Fig. 3. Fig. 3 (a) reveals the presence of many ponds and marshes in 1885, but few differences in the layout of roads compared with nowadays. Nine years later, in 1894, the area of water bodies such as ponds and





**Fig. 3(a)** Old Quarter in 1885 with Current Roads in 2005



**Fig. 3(b)** Old Quarter in 1894 with Current Roads in 2005



**Fig. 3(c)** Old Quarter in 1902 with Current Roads in 2005



**Fig. 4(a)** South Side of Citadel in 1890 with Current Roads in 2005

Note: Road plan is shown by dotted lines.

marshes had slightly decreased, while houses had increased (Fig. 3 (b)). These changes probably resulted from the continual filling in of the water bodies, which progressed in the subsequent decade to produce the situation shown Fig. 3 (c). For example, a pond located to the north of Hoan Kiem lake disappeared, and some houses were built. Street layout in 1902 was nearly parallel with the current situation. Also, the Dong Xuan market place (at the upper, central part of Fig. 3 (c)) in the Pho Co district can be recognized in 1902.

#### *Urban Development in the South Side under the French*

A practical development plan spanning approximately 15 years from the start of the French colonial period can be understood by comparing the 1890, 1898, and 1902 digital maps with the 2005 digital map. In the 1890 and the 1898 maps, the existing streets at that time and the planned streets are distinguished from each other and marked. Therefore, by using GIS technologies to extract only the existing streets of that time and the planned routes, the development plan of the period can be extracted and be compared on the timeline. The planned streets in 1890 are indicated by dotted lines, as shown in Fig. 4 (a). By comparing that to 1898, it was found that the plan for street development on the south side of Thang Long citadel had changed, and some planned streets had disappeared by 1898. These plans can be considered to have been aborted. In addition, the 1898 map shows a plan for a straight street running diagonally from the west side of the citadel toward the south of Hoan Kiem lake along Dien Bien Phu Str., but this does not match the current streets on the 2005 digital map, as shown in Fig. 4 (b). For example, a street running obliquely downward from left to right in the citadel



**Fig. 4(b)** Planned Roads and Existing Roads in 1898



**Fig. 4(c)** South Side of Hoan Kiem Lake in 1902 with Current Roads in 2005

does not parallel the current street. This could be another example of an aborted plan. On the other hand, the comparison also reveals that the development plan for new streets progressed steadily from 1898 to 1902. The construction generally proceed from east to west.

#### *Urban Change in and after the 20<sup>th</sup> Century*

How has the city of Hanoi changed since the beginning of the 20<sup>th</sup> century? This change can be recognized by comparing the maps from 1900 and later with the 2005 digital map, as shown in Fig.4 (c). The walls and moats of Thang Long citadel that were observed in the 1885 and 1890 maps had disappeared by 1902, as described above. In addition, several ponds and lakes that existed in 1890 and 1898 on the east and south sides of the citadel had disappeared by 1902, and a line of new buildings in that area can be seen. Furthermore, railways and tracks that do not appear in 1898 are visible in the 1902 map. It is considered that the railways that today run from Hanoi to northern Vietnam were built during this period. The present-day streets shown in the 2005 digital map match those in 1936 in the old quarter and south side of Hoan Kiem lake, as shown in Fig. 5. Therefore, the streets next to Hoan Kiem lake in Hanoi today were completed by 1936, while the area east and north of the Bay Mau lake and Kim Lien district were planned for development, as shown in Fig. 5.

#### *The Boundary between the Old Quarter and the Citadel*

Uncertainty about the boundary between the old quarter on the east side of the citadel and the citadel itself has given rise to debate among historians. However, it was possible to confirm



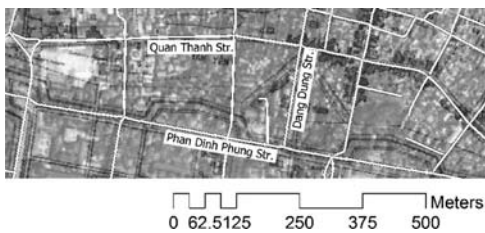
Fig. 5 Old Quarter and Area Near Bay Mau Lake in 1936



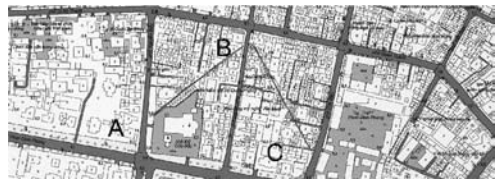
and verify the border using spatial analysis of maps and satellite images superimposed in a GIS system. The results of overlaying the 1885 map with the satellite image of 2005 are shown in Figs. 6 (a) and 6 (c), which indicate north and east sides of the citadel, respectively.

By overlaying the 1885 and 2005 digital maps as in Fig. 6 (a), signs of the wall and moat intersected Dang Dung Str. at the north side of the citadel can be recognized on the current map at the points marked A, B, and C in Fig. 6 (b).

The position of the wall and moat at the east side of the citadel between Phung Hung Str. and Hang Ga Str., which is the boundary between the old quarter and the citadel, can be estimated by overlaying the 1885 and 2005 maps as shown in Fig. 6 (c). The evidence, where the moat was once existed as shown in Fig. 6 (d) and Fig. 6 (e), was obtained from interviews



**Fig. 6(a)** North Wall and Moat of the Citadel in 1885 on the Satellite Image in 2005



**Fig. 6(b)** Range of Houses on the Current Map in 2005



**Fig. 6(c)** East Wall and Moat of the Citadel in 1885 on the Satellite Image in 2005



**Fig. 6(d)** Range of Houses on the Current Map in 2005



**Fig. 6(e)** Houses at Point in Fig. 6 (d): A

with local people in a field survey.

#### *Continual Filling in of Lakes, Ponds, and Marshes*

The change in the area of water bodies from 1885 to 2005 in central Hanoi was examined through the extraction of lakes, ponds, and marshes on the 1885, 1890, 1898, 1936, and 2005 maps. The basis for calculation is the 1885 map as shown in Fig. 7 (a). The distribution of water bodies is outlined in Figs. 7 (b)–(f). Table 1 and Fig. 7 (g) indicate the numerical change in the area. The water area decreased to 89.1%, 72.2%, 44.2%, and 22.8% in 1890, 1898, 1936, and 2005 respectively compared with 100% in 1885. Namely, the area decreased by 27.8% in the



**Fig. 7(a)** The Target Area



**Fig. 7(b)** Water Area in 1885

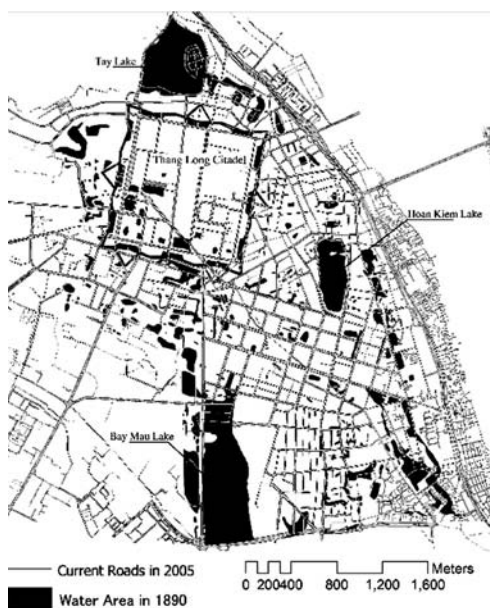


Fig. 7(c) Water Area in 1890



Fig. 7(d) Water Area in 1898



Fig. 7(e) Water Area in 1936



Fig. 7(f) Water Area in 2005



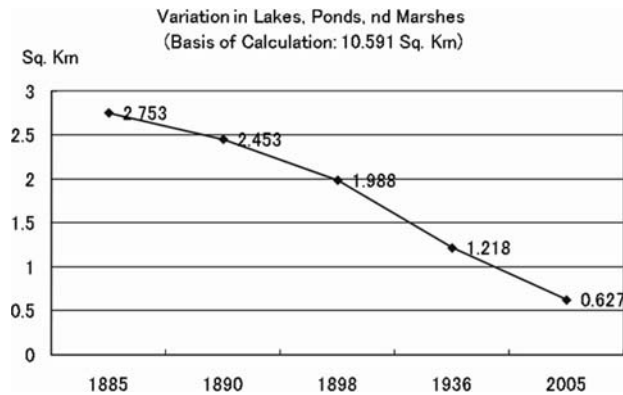


Fig. 7(g) Change in Area of Water Bodies

Table 1 Change in Area of Water Bodies

District	Variation in Lakes, Ponds, and Marshes (Basis: 10.591 Sq. Km)									
	1885		1890		1898		1936		2005	
	N	Sq.	N	Sq.	N	Sq.	N	Sq.	N	Sq.
Ba Dinh*	37	0.706	47	0.588	21	0.355	3	0.261	4	0.223
Dong Da*	165	0.563	67	0.297	50	0.628	44	0.192	3	0.042
Hoan Kiem	159	0.576	97	0.819	45	0.242	1	0.117	1	0.105
Hai Ba Trung	244	0.908	55	0.749	88	0.763	106	0.648	3	0.257
Total Area	605	2.753 100.0%	266	2.453 89.1%	204	1.988 72.2%	154	1.218 44.2%	11	0.627 22.8%

Note: \* Partial area

Unit.: Sq. Km

14 years from 1885 to 1898. A further 28.0% was lost in the 38 years from 1899 to 1936. By 1936, 55.8% of the area had been filled in. As a result, the filling in of lakes, ponds, and marshes progressed rapidly between 1885 and 1898 compared with the beginning of the 20<sup>th</sup> century.

### III Positions of the Old Hanoi Villages: Spatial Estimates Using GIS Technology

A map of 1873 gives an overview of the old villages in central Hanoi in the pre-colonial period, but it is difficult to estimate accurately the location and range of roads and buildings in those days because the map is hand-drawn. This also makes it difficult to investigate the incorporation of the villages into the city. The 1873 map was an image map, converted into a numerical map, and rectified against the 2005 base map and the satellite image of 2005 using the GIS system. The result of superimposition is shown in Figs. 8 (a) and 8 (b).

Using the numerical map on the GIS system, users can calculate the number of buildings, the length of streets, and the area of water bodies on the map, as shown in Fig. 8 (a). The result





**Fig. 8(a)** Distribution of Houses in 1873



**Fig. 8(b)** Houses in 1873 on the Satellite Image in 2005

of overlaying that onto the satellite image of 2005 is shown in Fig. 8 (b). The result allows readers to understand and overview the range of roads and houses in those days compared with the present-day. It is also appropriate to consider the incorporation of villages into the city. For example, the difference of brick or wooden house as building material can be identified by calculation of the number for it. However, the rectifying method in the GIS system might not be accurate in terms of location, depending on the accuracy of the source data. But, the estimation can be available. Then, the rectified 1873 digital map can be used as a base map to estimate the position of village before the French period on the GIS system.

#### *Estimated Positions of Old Villages, Prefectures and Districts*

To understand the significant transition to urbanization from the beginning of the French

**Table 2** Transition of Villages

District	Ward	1820	1831	1888
Tho Xuong	Thanh Nhan	20	19	8
	Yen Hoa	26	26	11
	Kim Lien	23	23	15
	Vinh Xuong	30	30	15
	Dong Xuan	17	17	14
	Dong Tho	19	19	13
	Phuc Lam	29	29	18
	Thuan My	29	30	22
Vinh Thanh	Yen Thanh	26	24	12
	Noi	10	10	9
	Thuong	7	7	7
	Trung	6	6	6
	Ha	7	7	6
Total		249	247	156

Source: Nguyen Vinh Phuc, Duong va Pho Ha Noi, NXBB Giao Thong Vantoi 2004



Fig. 9(a) Cadastral Document in 1805-1837

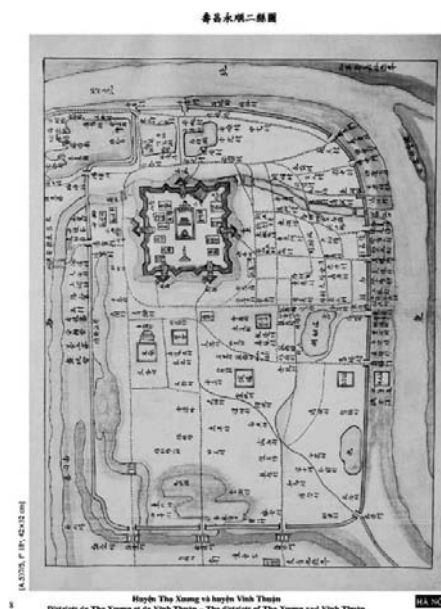


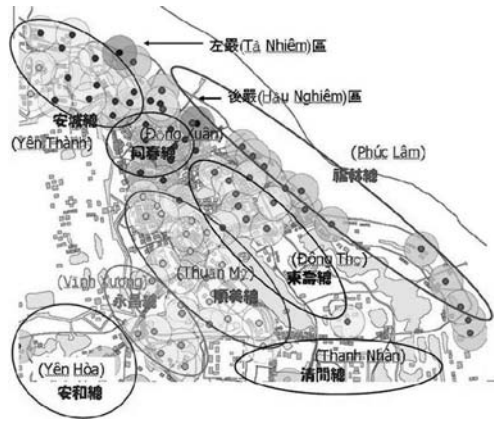
Fig. 9(b) Historical Villages in 1888

colonial period, it is necessary as a basic premise to accurately grasp the positions and distribution of the old villages and streets in the pre-colonial period. The change in the number of villages is shown in Table 2, focusing on the inside of citadel as shown in Fig. 1. The name of each village in the pre-colonial period can be found the land registers from the old village map in 1888 (data count: 168 villages) [Phan 2006]. These land registers and the “Districts of Tho Xuong and Vinh Thuan” map in Figs. 9 (a) and 9 (b) were used to map the individual villages onto the rectified 1873 map. Village names are shown only in Chinese-characters on the map. However, based on investigation using only materials above, there is no way to indicate such a village as an area with squares onto the digital map. Therefore, to accurately grasp the positional relationships between the 168 villages that were plotted, an informatics approach was applied.

First, the Voronoi distribution analysis method, which divides a region into several sub-regions in a way that is totally determined by the configuration of the data points, was applied to estimate the area of each village, as shown in Fig. 10. From these results, it was possible to estimate the land area of each of the villages and the adjacent relationships among the villages, and it was an effective method for comparing the scale of the villages using land area. Then, the result of combining this village mapping with the administrative classifications (districts, wards, villages) recorded in the cadastral document, is shown in Fig. 11. These results make it possible to estimate the positions and sizes of the districts, which are a higher order spatial unit than the villages. However, since this is a result of estimating areas through the geo-informatics approach, the boundaries of villages are not accurate.



**Fig. 10** Estimation of Village Locations in 1888 using Voronoi Diagram



**Fig. 11** Village and District Mapping in 1888

In order to prove the result, the village names written in the maps between 1885 and 1936 have to be compared together with the field survey. This investigation is beyond the scope of this paper.

### Network Analysis of Village Positions

Next, in order to confirm the relationship between the 168 villages that were plotted, the Network theory,<sup>\*1</sup> which indicates the relationship between keywords, here is the name of village extracted from the land register using a computer program, with a matrix consisting of

[illegible]

**Fig. 12** Translation of Cadastral Document (see Fig. 9 (a))

Note: Translation: Yano Masataka



**Fig. 14** Spatial Relationships between Village

keywords, was introduced. The keywords for the neighboring, bordering and facing villages, streets and buildings indicated on the north, south, east and west lines in the land registers based on Fig. 12 were taken as a first step, and then the positional relationships between them is inferred. Based on the results of extracting the keywords as shown in Fig. 13 using self-made computer program, it was possible to use Network theory\*<sup>1</sup> to visualize the spatial relationships between the old villages as shown in Fig. 14. By comparing and examining these

	F	G	H	I	J	K	L
Bk no.	List						
161	2085 2_16 Tượng Đài Vua Lê Thái Tổ	沿革 1896年造。以前には黎王廟があった。 伝、陳朝期抗元戦の犠牲烈士を祀る。のち荒廃。永佑年間(1735-39)、この地に cung Khánh Thụy を祠の東方に建築。Cungは1786年西山傳政時に破壊。1943年碑文によると、祠は1841年慈善会により修築。ここでは、 Bong Khánh Thụyにある寺den Ngọc Sơnと呼んでいる。Quan đế thánh quân, Văn Xương đế quân, Lễ Tế(Lễ Đổng Tàn)を祀る。		1896			
162	2086 2_33 Đền Ngọc Sơn	Chùa Lý Quốc Thám	以前はdenになった。旧Thọ Xuân縣Tiên Tú社總のTiên Thị村とChân Cảm,Tư Tháp村との境界の地。改築後現存する建築は仏堂に破壊された後1954年重修。嗣徳八年(1855)Cúc Hiên Lễ Đình Duyên撰撰文にこの年の大重修事跡を記す。Mình Không法師(-1141)を祀る。1138年、李神宗より開闢となり、làng Tiên Thiに封ぜられ、村民により祠が建てられた。	1735	1786	1841	
163	2087 2_20 Đền Phú Ứng	Chùa Lý Quốc Thám	ハノイにきたHải Hưngのlàng Phù Ung民が創建。Phạm Ngũ Lãoを祀る。何度も再建。1946年仏堂により破壊。のち再建。	1855	1138		1954
164	2088 2_39 Nhà thờ Lớn	Đền Phú Ứng	もとは1056年創建のchùa Báo Thiên驛のTháp Báo Thiênにあった。旧Thọ Xuân縣Tiên Tú社總(のち改名 Thuận Mỹ)Báo Thiên村屋。創建は1884-1886。ハノイ最大のキリスト教建築。		1946	1950	数世
165	2089 2_29 Đinh Nam Phụng	Nhà thờ Lớn	泰利を祀る。他にLong Đỗ, Cao Sơn, Linh Lang, Cổng chùa Hà Dụcを合祀。敷封によつて黎明期創設。重修繰り返す。ものと位置は現在のkhách sạn Phủ Gia。都市化の過程で、75 phố Hàng Trốngに移る。規模も縮小。	1056		1884	
166	2090 2_25 Chùa Phúc Long	Đinh Nam Phụng	阮前期創建。1973年・前より小規模ながら再興。				黎・仁
167	2091 2_42 Chùa Lăng	Đinh Nam Phụng	盛徳四年(1656)Nguyễn Văn Trạch撰Dương Trì Trạc枚の碑文に当時の景観を記す。創建は李朝期。禪師Từ Đạo Hạnhを祀る。英宗(1138-1175)による名称は Chiêu Thiện。改築は多数行。十九世紀に大大修。	1973			嗣復
168	2092 2_14 Đinh Kim Liên	Chùa Lăng		1656		1850	黎・仁
169	2093 2_14 Đinh Nam Đông	Đinh Kim Liên					
170	2094 2_14 Đinh Khương Thượng	Đinh Kim Liên	1772年創建。黎院朝期改度の重修。玉語によるとgò Con Quy(cử miếu Quy Sơn)創建。高駘、李太祖との関わり。のちlàng Khương Thượngの城壁となる。黎院朝における敷封(1642-1924)		1772		
171	2095 2_10 Đinh Kim Liên	Đinh Khương Thượng	別名đền Cao Sơn, もとの名Cao Sơn đại vương thần tử。高台のđồ Kim Hoaiに開ける地。山南と京城を分ける cửa ngõでもある。景興三十三年(1772)年に刻されている黎崇撰(洪順三年1510)の文に、黎襄翼帝による祠の再建事跡を記す。旧時の京城南部における特徴的な遺蹟。				黎平(16)
172	2096 2_6 Đinh Nam Đông	Đinh Kim Liên	làng Nam Đôngの城壁李常傑を祀る。				碑文
173	2097 2_24 Đinh Nam Đông	Đinh Kim Liên	Chế Bồng Nga軍を破ったPhạm Tô Thu và Phạm Ngưu Tậtを祀る。ほかにもThụy Tĩnh, Cầm châu, Trần Hưng etc				

Note: Translation: Yano Masataka





**Fig. 16** Historical Inscription  
Source: Sakurai Yumio

results superimposed with the Voronoi diagram, it became possible to more accurately estimate the positional relationships of the villages.

#### *Historical Mapping of Vestiges, Ruins, and Relics*

Vestiges and ruins are generally considered to occupy more than 2,000 sites in central Hanoi. The 150 most famous sites indicated by HPC (Hanoi People's Committee) and an example of relics provided by Sakurai are shown in Figs. 15 and 16 respectively. Analysis of these historical sources is expected to play an important role in investigating the urbanization from the viewpoint of social, political and anthropological aspects of human behavior in those days. Mapping as a thematic map for those sites is also in progress. As a result of mapping, the distribution by age of sites in Fig. 15 is shown in Table 3.

**Table 3** Distribution by Age of Historical Places and Archeological Sites (Total: 132)

Year	<1000<	<1200<	<1400<	<1600<	<1800<	<2000
Number	9	18	7	18	35	45

Note: Year: established

#### *Identifying of the Old Gates of the Thang Long Area*

The boundaries of the old Thang Long area are yet to be established. It is necessary to clarify the boundaries and gates of the area in order to investigate the urbanization from the view point



**Fig. 17(a)** Estimation of Gates and Thang Long Area



**Fig. 17(b)** Estimation of Gate Positions  
(expectation: (12) and (13))



**Fig. 17(c)** Wall Remaining in 1902

**Table 4** Position of Old Gates

Location	Street Name and Intersection
(1)	Thanh Nien and Duong Nghi Tam
(2)	Bac and Nguyen K. Nhu
(3)	Nguyen Thiep and H. Dau
(4)	H. Chieu and Dao D.Tu
(5)	Ma May
(6)	H. Bac and Ng. Huu Huan
(7)	Lo Su and Ng. Huu Huan
(8)	Trang Tien and Ng. Huu Huan
(9)	Lo Duc and Tran Khat Chan
(10)	Pho Hue and Tran Khat Chan
(11)	Le Duan and Dai Co Viet
(12)	Ton Duc Thang and La Thanh*
(13)	Giang Vo and La Thanh*
(14)	Ngoc Ha and Son Tay
(15)	Thuy Khue and nearby Hung Vuong

Note: \* Presumed by Shibayama based on the 1888 village map (Fig. 9 (b))

partially seen on the 1885 map, and it should therefore be effective to superimpose the 1885 digital map on the 2005 digital map. The result of superimposing the 1885 map onto current roads in 2005 is shown in Fig. 17 (a). According to the village map of 1888 discussed in the previous section, the Tang Long area had 15 gates; and 13 of these gates can be identified based on the 1885 map as shown in Fig. 17 (b). The current position of each gate was estimated as shown in Fig. 17 (b) on the GIS system, and identified as shown in Table 4.

To prove the above estimation, I conducted a field survey together with Sakurai as shown in Figs. 18 (a)–18 (d). Fig. 18 (a) shows the extant gate at a position (4) in Fig. 17 (b). And, Fig. 18 (b) shows position (11) in Fig. 17 (b). Sakurai also discovered the site of an old wall as shown in Fig. 17 (c), near the route from position (9) to (10) as shown in Figs. 18 (c) and 18 (d) respectively.



**Fig. 18(a)** Extant Gate at Position (4)



**Fig. 18(b)** Scenery at Position (11)



**Fig. 18(c)** Ruin of Wall at Position (9)



**Fig. 18(d)** Ruin of Wall at Position (9)

#### IV Three-dimensional Topographical Landscape Model

Three-dimensional (3D) spatial analysis can contribute to understanding the problems of how so many lakes and ponds disappeared, by what processes the construction of the levees on the west bank of the Red River progressed, and how these affected all of the transformations of the urban environment during urbanization from the latter half of the 19<sup>th</sup> century through to the beginning of the 20<sup>th</sup> century. Therefore, an attempt was able to create a 3D landscape model for understanding the difference between 1885 and 2005 from a bird's-eye perspective [Yonezawa and Shibayama 2008: 228].

##### *Construction of a Three-dimensional Urban Landscape Model*

In the 2005 map, the number of stories of the houses, which indicates their height, is listed for each block of houses. If these blocks and the number of stories are entered into a GIS system as three-dimensional data (called a “feature” in the GIS system), it is possible to generate a three-dimensional urban landscape model as shown in Figs. 19 and 20. Yonezawa is currently entering approximately 700,000 data points as the number of stories with their position



**Fig. 19** Topographic Map Using DEM  
Source: Yonezawa Go



**Fig. 20** 3D Hanoi Landscape Model  
Source: Yonezawa Go

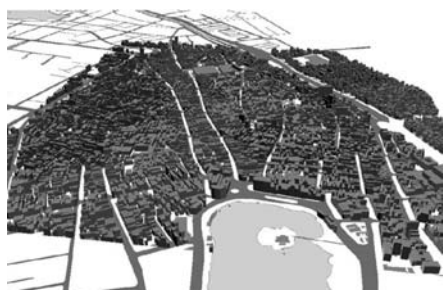




**Fig. 21(a)** Building Data in the Old Quarter in 2005



**Fig. 21(b)** Houses in the Old Quarter in 1885  
Source: Ota Shoichi



**Fig. 22(a)** 3D Model of Landscape in 2005



**Fig. 22(b)** 3D Model of Landscape in 1885

[Yonezawa and Shibayama *et al.* 2008]. Expressing each feature using a timeline makes it possible to restore the urban landscape of that time. This includes the distribution of thatch and wood homes, as described above. In addition, it becomes possible to create an overview of how the current urbanization is advancing in the places where the lakes and ponds existed in the past.

The density of the blocks of houses as a 2D expression is shown in Fig. 21 (a) for 2005 and Fig. 21 (b) for 1885. Fig. 22 (a) shows the landscape in 2005 as a bird's view eye after entering the appropriate height value for each block of buildings. Fig. 22 (b) shows an urban restoration derived by modeling based on the 1885 digital map shown in Fig. 21 (b). Here, it is assumed that the height of the blocks of buildings is the same in all the blocks.

Comparing the landscapes in 2005 and 1885, it is evident that (1) the water area decreased as greatly described above. In particular, the citadel moat disappeared along with the wall. (2) The density of building per unit area in 2005, of course, differs from that in 1885.

## V Discussion

In the previous section, urban transformation from the latter part of the 19<sup>th</sup> century through the beginning of the 20<sup>th</sup> century was observed using an area informatics approach. The



transformation consisted of changes in Thang Long citadel, the old quarter, and the south side of the citadel, and changes in the 20<sup>th</sup> century and later. Such observations clarified what sort of development occurred, especially, in relation to Sakurai's hypothesis that "significant urban development and transformation" occurred in those days.

#### *Significant Urban Development and Transformation*

From the results of various observations, it can be concluded that "significant urban development" proceeded for approximately 10 years between 1890 and 1900. The conclusion rests on the following points.

- (a) Changes in Thang Long citadel: Increase of military plant and barracks can be seen by comparing the digital maps of 1885, 1890, and 1902. This result supports the hypothesis generated by Sakurai.
- (b) Transformation in the old quarter: the continual filling in of ponds and marshes expanded in the same period. In particular, the citadel wall and moat were clearly destroyed by the French. Also, a railway line was constructed along with the east side of the citadel.
- (c) Urbanization in the south side of citadel: Observation and comparison of the three maps of 1885, 1898, and 1902 reveals that several urban development plans were attempted by the French. Such development rapidly progressed westward from the west bank of Red River to the south side of Hoan Kiem lake and Thang Long citadel, together with settling new villages on the river bank. These developments also progressed during the same period. However, the area near Bay Mau lake and Kim Lien district were developed after the start of the 20<sup>th</sup> century, because the map of 1902 shows no development plans there.
- (d) Gates positioned at the border of Thang Long area: All 15 gates shown in the historical map in 1888 and the map of 1885 had clearly disappeared by 1902. It is concluded that the disappearance was caused by the development of new roads and residential areas in the same period.

#### *New Findings on Area Informatics Approach*

Several new findings on the geo-informatics approach were also derived in this study. Geo-informatics can be considered in part to be subsumed in area informatics, a discussion of which lies beyond the scope of this paper. Thus, only new findings on the spatial analyses are described here. Research on geo-informatics using the GIS/RS, which employs spatial analyses and the function of visualization generally, can be effective and useful in area studies for gaining an overview and understanding of transformations and topographic features in a specific area.

Such new findings were as follows. (1) Several plans for road construction on the timeline from 1885 to 1902 were found to have been aborted. This result came out of GIS technology, which allows the superimposing of a shape described on one map onto another map. When the plans for the road development together with the existing roads were extracted from the map of 1885 and superimposed on the map of 1898, it was found that several planned roads had disappeared in 1898 and 1902. (2) Uncertainty about the boundary between the old quarter on

the east side of the citadel and the citadel itself had been a source of debate among historians, but it was possible to confirm and verify the border using the spatial analysis of maps and satellite images superimposed on the GIS as shown in Fig. 6. The same result was derived by superimposing the maps of 1885 and 2005. (3) A new hypothesis was introduced by generating a bird's-eye view at the old quarter using 3D modeling. Namely, an outstanding feature of the buildings constructed after the filling in of ponds, marshes, and lakes is that they were much higher than the buildings that existed in 1885, as shown in Fig. 22 (a).

#### *Additional Discussion for Area Informatics Approach*

Applying geo-informatics for analyzing specific area can be effective and useful from the viewpoint of allowing easier map comparison and overlaying, the discrimination of features on the map, the numerical calculation of the areas and the distances, the locations, and so on, and 3D modeling. The typical functions used in this study were the map comparison on the timeline, the square calculation for water area, and 3D modeling for comparing landscapes. In addition, simulation methods such as the Voronoi diagram and Network theory\*<sup>1</sup> were used for analyzing village locations and the relation between adjacent villages. Through this study, it can be said that geo-informatics was very effective in investigating the urbanization of Hanoi as described above. However, in the observation of the transition of villages on the periphery of the citadel, the relationship between development and the transition of villages remains to be clarified through estimation on the maps and confirmation by field survey.

## **VI Conclusion: The Area Informatics Approach**

In the research on the formation of the city of Hanoi described in the previous section, a base map based on 2005 satellite images was created, and six maps from 1885 through 1936 were superimposed on the base map. Then, spatial analyses were carried out to compare and examine urban transformation. This is a real-world example of identifying spatial positions on numerous target maps and eliminating arbitrariness to decipher the temporal changes in the phenomena expressed on the maps. Next, the accurate superimposition of the maps, accompanied by field research, yielded some conclusions regarding the history and location of the border between the old citadel and the old quarter, which have been in dispute among historians. In addition, quantitative analyses and estimates were also possible of the land areas of the Thang Long citadel and villages, the distances between the villages, the distribution, densities and positions of the villages based on an 1888 illustrated map, the differentiation between wood or brick in home-building materials in 1873, a timeline of the construction of the levees and the disappearance of lakes and ponds, as well as the distribution of ruins and historical sites and the distribution of historical relics and inscriptions. By building a three-dimensional topographical model, it also was able to clearly see the landscape with a bird's-eye view.

We believe that research on the process of urban formation in Hanoi as well as research on

the topographical changes from 1885 onward make it possible to comprehensively and multi-dimensionally survey the Hanoi area by creating relationships between the “place” and “time” of individual events and phenomena, including approximately 2,000 historical sites, many thousands of monument inscriptions and sociological data. In other words, the individual events and phenomena (hereinafter, “phenomena”) within the expanse of space and time can be mapped, and the mutual relationships between these phenomena can be understood. When these phenomena are viewed from the perspective of spatial informatics, they are expressed in terms of “position” and “elevation,” as shown in the landscape of Hanoi. In other words, they are expressed in three-dimensional space. When a temporal axis is added, a four dimensional spatiotemporal model can be implemented. We have introduced informatics to area studies, and we believe that this makes it possible to more clearly understand the structure and function of areas within a four dimensional spatiotemporal model. This is because we believe this may allow us to see the overall movement and dynamism of areas. The task is to investigate the village transition in the latter part of the 19<sup>th</sup> century and the transformation of Hanoi after the year 1900 by means of an area informatics approach.

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Note: \*1: Network theory is an area of applied mathematics and part of graph theory which is the study of graphs: mathematical structures used to model pair-wise relations between objects from a certain collection. The Network theory concerns itself with the study of graphs as a representation of either symmetric relations or, more generally, of asymmetric relations between discrete objects. Examples of which include logistical networks, social networks, and so on. In this paper, an object corresponds to a village in the cadastral document.

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